ATTACHMENT E		Page 1 of 2		
Becton, Dickinson and Company				
Mass Balance Calculations for SIP Application **(PTE)**				
Facility:	Covington, GA			
Input data:				
Ethylene oxide usage		534,000	lb/yr	Total usage based on Mass Balance
Sterilizer removal efficency[1]		99.9%		Based on partial pressure calculation estimate
RTO efficiency, aeration		99.970%		Based on 2019 Performance Testing
RTO efficiency, vessels		99.999%		Based on 2019 Performance Testing
Product transfer time, sterilizer to aeration		5	min	
Aeration time		16	hr	
Aeration Unload time		10	min	
System 1 removal efficiency		99%		Assume 99% Based on vendor literature
System 2 removal efficiency		99%		Assume 99% Based on vendor literature
System 2 Safety Factor		4.00		Safety factor included to account for variation in future products and product density which may impact EO residuals.
Assumptions:				
Product absorption[2]		0.4%		
EO degassing rate constant, k[3]		0.06151	lb/hr	
Miscellaneous fugitive loss[4]		100	lb	captured in system 1
Calculations:				
Sterilizer:				
EO into sterilizers		533,900	lb	Total usage based on Mass Balance minus miscellaneous fugitive loss
EO absorbed by product		2,135.6	lb	
EO in sterilizer not absorbed by product		531,764.4	lb	
EO exhausted to RTO from vac/air wash		531,232.6	lb	
EO exhausted to RTO from vent		531.8	lb	
Sterilizer exhaust to RTO		531,764.4	lb	
Sterilizer exhaust removed by RTO		531,759.1	lb	
Sterilizer exhaust to atmosphere after RTO		5.3	lb	
Transfer:				
EO offgas during product transfer to aeration		0.51%		EO will off-gas from products during aeration per equation: $C = C_o e^{(-kt)}$, where C = Final EO concentration, C_o = EO concentration at time 0, k = EO degassing rate constant, and t = degassing time in hrs.
EO offgas during product transfer to aeration		10.9	lb	This will be captured by system one
Aeration:				
EO remaining in product entering aeration		2,124.7	lb	
Offgas during aeration		62.6%		
Offgas during unloading		0.0		
EO offgas during aeration		1,330.6	lb	
To RTO during aeration		1,330.6	lb	
To RTO during aeration unload		8.1	lb	
Total aeration to RTO		1,338.7	lb	
Aeration removed by RTO		1,338.3	lb	
Aeration exhaust to atmosphere after RTO		0.4	lb	
System1:				
Into System 1		110.9	lb	
Removed by System 1		109.8	lb	
System 1 exhaust to atmosphere		1.1		
System2:				
Into System 2		3,144.0	lb	Includes System 2 Safety Factor
Removed by System 2		3,112.6	lb	
System 2 exhaust to atmosphere		31.4		
Exhausted before Modification:				
EO exhausted to atmosphere from RTO		5.7	lb	
EO Exhausted to atmosphere by system 1		110.9	lb	
EO Exhausted by to atmosphere System 2		786.0	lb	Does not include Safety Factor[5]
Total EO exhausted to atmosphere		**902.6**	**lb**	**Before Modifications**
		0.5	**Tons**	
Exhausted after Modification:				
EO exhausted to atmosphere from RTO		5.7	lb	
EO Exhausted to atmosphere by system 1		1.1	lb	
EO Exhausted by to atmosphere System 2		31.4	lb	Does include Safety Factor
Total EO exhausted to atmosphere		38.3	**lb**	
		0.019	**Tons**	**After Modifications**
Note 1	This estimates how much EO is removed during post exposure vacuum washes but does not include what is in the product at the time it transfers to Aeration			
Note 2	Estimates the amount of EO in the product when it starts the transfer to aeration			
Note 3	An estimate based on Product EO Residue Testing performed by BD laboratory personnel.			
Note 4	An estimate of potential EO emissions from pump/valve packaging, flange losses, EO supply drum changes, and non-routine losses.			
Note 5	The Safety Factor is only included in the After Modification calculations as this insures the new System is designed to account for variation in future products and product density which may impact EO residuals.			